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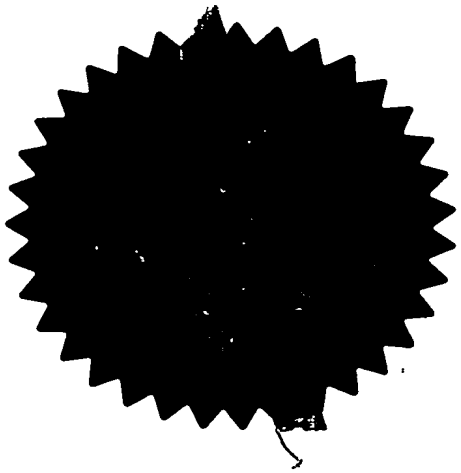

Signed P. Mahoney

Dated 6 October 2004

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Patents Form 1/77

Patents Act 1977
(Rule 16)

The Patent Office

225EP03 E838900 2 002838
P01/7700 0.00-0322120.7

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

2 2 SEP 2003

The Patent Office

Cardiff Road
Newport
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1. Your reference

BKCD/AFD/HICKS.3

2. Patent application number
(The Patent Office will fill this part in)

0322120.7

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

R J Hicks
Mayo Hall
Llangammarch Wells
Powys LD4 4BS

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

08568941001

4. Title of the invention

Lightweight Gearing

5. Name of your agent *(if you have one)*

Wynne-Jones, Laine & James

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

22 Rodney Road
Cheltenham
Gloucestershire GL50 1JJ

Patents ADP number *(if you know it)*

1792001 ✓

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute (see note f)

Number of earlier UK application	Date of filing *(day / month / year)*

8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request?

No

Answer YES if:

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.

Otherwise answer NO (See note d)

Patents Form 1/77

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9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form	
Description	4
Claim(s)	1 CF
Abstract	–
Drawing(s)	1 only

10. If you are also filing any of the following, state how many against each item.

Priority documents	–
Translations of priority documents	–
Statement of inventorship and right to grant of a patent (Patents Form 7/77)	–
Request for a preliminary examination and search (Patents Form 9/77)	–
Request for a substantive examination (Patents Form 10/77)	–
Any other documents (please specify)	–

11. I/We request the grant of a patent on the basis of this application.

Signature(s) Wynne Jones Laine & James Date 22.9.03

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom

Mr B Dunlop 01242 525807

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'YES' in part 6, a Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) Part 7 should only be completed when a divisional application is being made under section 15(4), or when an application is being made under section 8(3), 12(6) or 37(4) following an entitlement dispute. By completing part 7 you are requesting that this application takes the same filing date as an earlier UK application. If you want the new application to have the same priority date(s) as the earlier UK application, you should also complete part 6 with the priority details.

Lightweight Gearing

The present invention provides a high ratio epicyclic gear assembly with high efficiency and minimum volume and weight. While it may be used either for speed reducing or increasing applications, it is particularly suited for the latter, especially for wind turbo-generator drives in which torque and overall speed step-up ratio increase with power causing disproportionate increases in gearbox weight; e.g. a 3000 kW turbine runs at 35% of the speed and has 22.6 times the torque of a 375kW machine. This means that an eight fold increase in power increases the weight of the associated gearbox by a factor of over 22.6. This invention enables a gearbox not only to be less than half the weight of a conventional gearbox, but also to have lower gear tooth stresses, longer life bearings and higher overall efficiency.

Since gear box manufacturing costs are primarily governed by weight and since this in turn influences nacelle and tower weights, then significant savings can be made in a complete installation.

This invention therefore, exploits the fact that an epicyclic gear with a low basic annulus to sun ratio can accommodate a greater number of planet wheels than a gear with a high ratio. Furthermore, the lower the ratio, the more efficient the gear becomes when used in a planetary configuration with a stationary annulus because the lower relative speed of the sunwheel with respect to the planet carrier, ensures that a greater proportion of the throughput power is transmitted by a direct coupling effect. Since a planet carrier has a torque equal numerically to the sum of the sun and annulus torques, then to minimise volume, it should always be used as the high torque member in a transmission. However,

to realise the full benefit of using more than three planets it is essential to have an effective means of sharing the load equally between them e.g. the flexible pin planet spindle which enables the maximum number to be used subject only to the clearance between adjacent planet tip diameters.The key feature of this invention is that total input torque is equally divided between two low ratio primary planetary trains that transmit power along two parallel paths. These low ratios stem from the use of a secondary differential train to re-combine the separated power flows into a single output. The resultant overall speed increasing ratio is effectively doubled and for a given output speed, the primary ratios can be halved. This enables more planets to be used so that there is a significant reduction in collective weight and component sizes.

According to one embodiment of this invention, as shown in figure1, the input power and torque of a speed increasing gear are divided between the planet carriers 1 and 2 of two planetary trains with equal powers flowing from their respective sunwheels 3 and 4. The first sunwheel drives the planet carrier 5 of a differential train while the second sunwheel drives the differential annulus 6 via an intermediate star train 7 at the required speed and sense of rotation necessary to precisely equalise the powers in the respective primary trains irrespective of relative torsional deflection between the inputs to the two planet carriers.

While it is quite feasible to have the same annulus to sun ratios of 2.8 in the two primary planetary trains and corresponding ratios of 1.62 in the intermediate star and differential trains to give an overall speed increasing ratio 20/1, a larger overall ratio may be obtained if the second primary train ratio is

somewhat less than the first as this enables the ratio of the low torque differential train to be increased e.g. respective annulus to sun ratios of 2.8 and 2.15 in the two high torque primary and 1.54 and 3.6 in the low torque intermediate and differential trains give an overall ratio of 35/1. With such ratios, flexible planet spindles enable 6 and 8 planets to be accommodated in the primary trains with 12 and 5 in the intermediate and differential trains.

Notwithstanding the four trains in this arrangement, the split power paths and low ratios with multiple planets having small diameters, ensure that relative pitch line velocities, tooth loads and the overall associated losses are lower than those in a conventional two stage gear having the same overall ratio.

As shown in figure 2, by introducing an intermediate solar train 8 i.e. (with a stationary sunwheel reaction member) into the first power path to the differential planet carrier and increasing the ratio of the intermediate star in the second path to the differential annulus, the differential annulus to sun ratio can be increased to 5.1 (with 4 planets) to give an overall ratio of 70/1. Since this can be done without changing the primary high torque planetary ratios, there is a relatively minor increase in weight due mainly to the additional low torque solar train.

Figure 3 shows that overall ratio can be increased even further to 120/1, again without significant increase in weight, by changing from a solar to a planetary intermediate train 9 in the first path and increasing the intermediate star ratio in the second path but leaving the primary and differential ratios the same as figure 2.

Further variations of the intermediate and differential train ratios can effect sufficient increases in overall ratio to ensure that there is no need for more than five trains for any currently envisaged wind turbine powers and speeds. However, it is feasible to divide the transmission into three or more parallel power paths with a double or multiple differential integrating arrangement.

The choice of overall epicyclic ratio and the number of trains that this entails is governed by the installation architecture e.g. whether or not an offset output shaft is required. It is also dependent on the embodiment of additional torque limiting and/or variable ratio mechanisms. To minimise volume and weight, these are preferably located at the high speed/low torque output stage, before the final drive to the generator.

Claims

1. A high ratio epicyclic gear assembly comprising first and second low ratio primary planetary trains for transmitting power along two parallel paths and a secondary differential train for combining the power flows in the planetary trains into a single output wherein the primary trains are arranged to share substantially equally the total input torque.

2. An assembly as claimed in claim 1 further comprising an intermediate gear train drivingly located between one primary planetary train and one half of the differential train.

3. An assembly as claimed in claim 2 where the intermediate gear train is a star train

4. An assembly as claimed in any one of the preceding claims where the gear ratio in one primary train is lower than the other.

5. An assembly as claimed in any one of the preceding claims wherein the secondary differential train is a planetary train.

6. An assembly as claimed in claim 5 when dependent on claim 4 wherein the primary planetary chains have 6 and 8 planets respectively and the intermediate and differential trains have 12 and 5 respectively.

7. An assembly as claimed in claim 4 including an intermediate solar train connection between a primary train and the planet carrier of the differential train.

8. An assembly as claimed in claim 6 wherein the solar train is replaced by a planetary intermediate.

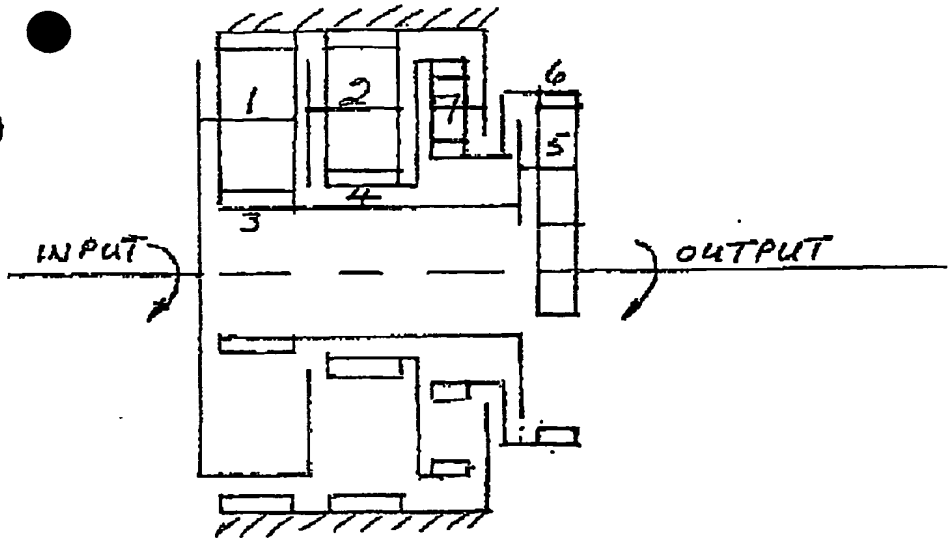


FIGURE 1 RATIO 35/1

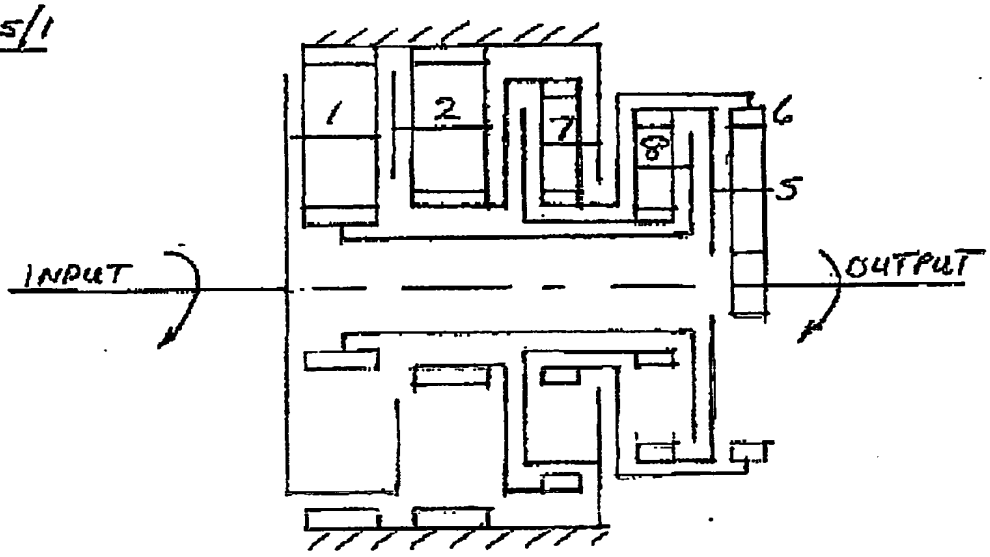


FIGURE 2 RATIO 70/1

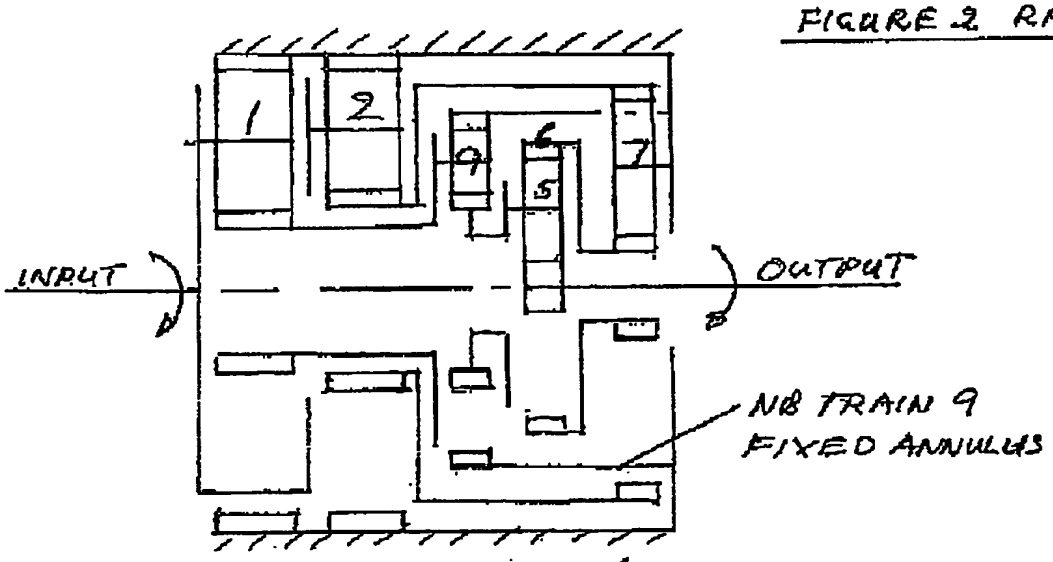
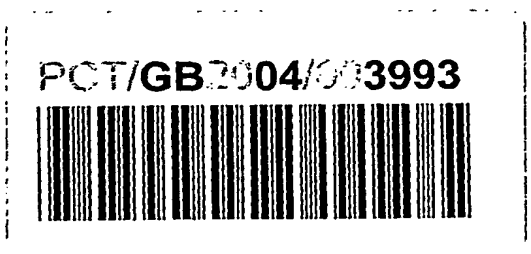


FIGURE 3 RATIO 120/1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